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Review

The management of household hazardous waste in the United Kingdom

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ABSTRACT

Waste legislation in the United Kingdom (UK) implements European Union (EU) Directives and Regulations. However, the term used to refer to hazardous waste generated in household or municipal situations, household hazardous waste (HHW), does not occur in UK, or EU, legislation. The EU's Hazardous Waste Directive and European Waste Catalogue are the principal legislation influencing HHW, although the waste categories described are difficult to interpret. Other legislation also have impacts on HHW definition and disposal, some of which will alter current HHW disposal practices, leading to a variety of potential consequences. This paper discusses the issues affecting the management of HHW in the UK, including the apparent absence of a HHW-specific regulatory structure. Policy and regulatory measures that influence HHW management before disposal and after disposal are considered, with particular emphasis placed on disposal to landfill.

1. Introduction

Legislation, and the policy that underlies it, is crucial to the management of all types of waste, including household hazardous waste (HHW). Currently, waste management in the United Kingdom (UK) is governed through the implementation of European Union (EU) legislation. The UK had already started along the path to improving environmental protection from the disposal of waste just before the EU. The Royal Commission on Environmental Pollution was established in 1970, partly because of concerns over waste disposal. The Deposit of Poisonous Waste Act 1972 (Statutory Instrument, 1972) was rapidly drafted soon afterwards. The Control of Pollution Act 1974 (COPA) (Statutory Instrument, 1974) followed, aimed at a more extensive control of waste disposal and regulation of disposal sites. Controls applicable to "special waste", a phrase used for hazardous or dangerous wastes, were incorporated into legislation through the Control of Pollution (Special Waste) Regulations 1980 (Statutory Instrument, 1980). Since 1975, with the Waste Framework Directive (WFD) 75/442/EEC (recently re-codified as 2006/12/EC) the EU adopted responsibility for the development of waste legislation (European Council, 1975; European Parliament and Council, 2006a). Initially, the aim of EU policy and legislation was the standardisation of the statutes of the Member States. As the EU has developed, the remit has also changed, now focusing on improving the legislation of all Member States.

This paper will evaluate the key legislation affecting the management, from collection to final disposal, of household hazardous waste (HHW) as permitted in the UK through the enactment of EU Directives. HHW, a term that can be used to describe hazardous waste in the household fraction, is usually used only to describe waste of domestic origin but can also be applied to municipal hazardous waste. "Leftover household products that contain corrosive, toxic, ignitable, or reactive ingredients" is the description provided by the US-EPA (United States Environment Protection Agency, 2005). The UK-based National Household Hazardous Waste Forum (NHHWF) describes HHW as "any material discarded by a household which is difficult to dispose of, or which puts human health or the environment at risk because of its chemical or biological nature" (National Household Hazardous Waste Forum, 1999). As previous work has described, the HHW stream is generally poorly quantified due to a combination of poor definition (of component wastes) and through a perception that it is too small to be significant (Slack et al., 2004). However, upwards of 100,000 tonnes of HHW, not including the bulkiest component of HHW, waste electrical and electronic equipment (WEEE), can be expected to be disposed of each year in the UK (Burnley et al., 2007; Slack et al., 2004, 2005, 2007a). There is also evidence that HHW disposal to landfill sites contributes toxic substances to the landfill leachate that forms through a process of rainwater infiltration and decomposition of the waste body. Whilst most modern UK landfills possess leachate collection and treatment capability, it tends not to last the lifespan of the pollution potential of a landfill, which can be in excess of several thousand years and hence poses a long-term risk to the environment and human health. It is therefore important to assess the status of HHW as a waste stream in UK and, by default, EU legislation.

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2. European Union waste policy and legislation

The scope of the EU has expanded from predominantly economic co-operation between European countries prior to 1967 to include, among other social, legal and economic aspects, environmental protection. To date, Europe has developed policy and legislation incorporating, for example, the areas of natural resources and waste, nature and biodiversity, environment and health, and climate change. All policy informs legislation, which takes the form of Directives, Regulations and Decisions. Environmental policy determines the principal objectives to be addressed through legislation and defines future proposals for further discussion. Environmental, and waste, legislation in the EU results from the policy decisions laid out in the sequential series of Environmental Action Programmes (EAPs) and Waste Management Strategies.

Directives represent the legal obligations required of all Member States and must be transposed into national legislature. For waste, the re-codified Waste Framework Directive (WFD) 2006/12/EC establishes the basis for EU waste management (European Parliament and Council, 2006a). The Hazardous Waste Directive (HWD) 91/689/EEC (European Council, 1991a) further develops legislation with regard to hazardous waste only, specifying the properties that render waste hazardous and therefore applicable to the management structures outlined in the WFD. Changes to waste legislation in the future may see the measures of the HWD integrated into the WFD (European Commission, 2005), possibly by 2008. A list of the wastes falling within the scope of the WFD and HWD is provided in separate legislation, the European Waste Catalogue (EWC) 2000/532/EC (European Commission, 2000). Integrating an expanded Hazardous Waste List 94/904/EC, the EWC, as amended by Decisions 2001/118/EC, 2001/119/EC and 2001/573/EC, is subject to the articles of the HWD (European Commission, 2000, 2001a,b; European Council, 1994, 2001).

Other EU Directives focus on technical aspects of waste management, such as the Landfill Directive (LFD) 99/31/EC, or on particular waste streams through the application of producer responsibility, including the Waste Electrical and Electronic Equipment (WEEE) Directive 2002/96/EC, the End-of-Life Vehicles (ELV) Directive 2000/53/EC, and the Batteries and Accumulators Directive 2006/66/EC (European Council, 1999; European Parliament and Council, 2000, 2002a, 2006b).

European legislation regarding waste has increased considerably since 1975, reflecting the waste policy of the EAPs. The amount of legislation has led to varied rates of transposition into the national law of Member States and certain Directives are still in the process of full implementation. The UK has only recently fully implemented the WFD with regard to agricultural waste and is still in the process of full transposition of the WEEE Directive. Original implementation of the HWD was through the Special Waste Regulations 1996 (SWR) (Statutory Instrument, 1996), which amended the special waste legislation provided in the Control of Pollution (Special Wastes) Regulations 1980 according to the European Directive (Statutory Instrument, 1980). However, the SWR did not allow full realization of the HWD. This led to the development of the Hazardous Waste (England and Wales) Regulations 2005 (HWR) (Statutory Instrument, 2005a), which fully implement the HWD. Similarly, the European Waste Catalogue has only recently been fully transposed into UK legislation with, for instance in England, the List of Wastes (England) Regulations 2005 (Statutory Instrument, 2005b), which replaces UK-specific classifications.

3. Household hazardous waste and legislation

Notably focusing on industrial and larger commercial waste streams, the HWD makes mention of hazardous waste with municipal origin, which can be considered to include HHW. However, the references to such waste appear to be contradictory. The HWD incorporates lists of wastes and activities generating wastes that are considered to display hazardous properties in Annexes I and II. Household hazardous waste, whether or not it is separately collected, is excluded from the HWD under Article 1(5) and yet permitted, as separate fractions, by the same legislation through Annex IB(39) despite the proviso appearing in Annex IB(40) that states "any other wastes which contain any of the constituents listed in Annex II and any of the properties listed in Annex III" can be considered to be hazardous (Box 1). This

Box 1. Abstracts from the European Union's Hazardous Waste Directive (European Council, 1991a) pertinent to household hazardous waste. Note the use of terms "domestic" and "household" alongside absence of reference to municipal waste.

Hazardous Waste Directive (91/689/EEC):

- Article 1 (5) – 'Domestic waste shall be exempted from the provisions of this Directive. The Council shall establish, upon a proposal from the Commission, specific rules taking into consideration the particular nature of domestic waste not later than the end of 1992.'
- Article 2 (2) – '…do not mix different categories of hazardous waste or mix hazardous waste with non-hazardous waste.'
- Annex IA – 'Wastes displaying any of the properties listed in Annex III and which consist of:
  2. pharmaceuticals, medicines and veterinary compounds;
  3. wood preservatives;
  4. biocides and phyto-pharmaceutical substances (e.g. pesticides, etc.);
  5. residue from substances employed as solvents;
  8. mineral oils and oily substances;
  9. oil/water, hydrocarbon/water mixtures, emulsions;
  12. inks, dyes, pigments, paints, lacquers, varnishes;
  13. resins, latex, plasticizers, glues/adhesives;
  16. photographic chemicals and processing materials' may be classified as hazardous.
- Annex I B (39) – 'materials resulting from selective waste collections from households and which exhibit any of the characteristics listed in Annex III' can be considered hazardous.
- Annex I B (40) – 'any other wastes which contain any of the constituents listed in Annex II and any of the properties listed in Annex III.
- Annex II – 'Constituents of the wastes in Annex I B, which render them hazardous…… C5 nickel compounds; C6 copper compounds; C7 zinc compounds; C8 arsenic compounds; C11 cadmium, cadmium compounds; C16 mercury, mercury compounds; C18 lead, lead compounds; C21 inorganic cyanides; C23 acidic solutions/solid form; C24 basic solutions/solid form; C33 pharmaceutical or veterinary compounds; C34 biocides and phyto-pharmaceutical substances; C36 creosotes; C39 phenols, phenol compounds; C40 halogenated solvents; C41 other organic solvents; C42 organohalogen compounds; C43 aromatic, polycyclic, heterocyclic compounds; C44/45 aliphatic/aromatics amines; C51 hydrocarbons.'
- Annex III – Properties of wastes which render them hazardous: H1 Explosive; H2 Oxidizing; H3A Highly flammable; H3B Flammable; H4 Irritant; H5 Harmful; H6 Toxic; H7 Carcinogenic; H8 Corrosive; H9 Infectious; H10 Teratogenic; H11 Mutagenic; H12 Substances/preparations which release toxic gases; H13 Substances/preparations yielding hazardous substances after disposal; H14 Ecotoxic.

demonstrates the confusion concerning definitions of waste origin. Reference to "domestic" waste in Art. 1(5) and "household" in Annex IB(39) indicate that whilst hazardous waste from households only is exempt from hazardous classification, separately collected municipal fractions, such as at household waste recycling centres (HWRCs), are not. However, no measures are recommended to ensure all hazardous elements of the municipal waste stream are separated from non-hazardous waste. The EWC considers only separately collected fractions as potentially possessing hazardous properties (chapter 20 01): mixed municipal waste (described by the six-digit waste code as 20 03 01), regardless of content, must always be non-hazardous. Co-disposal of HHW, provided it has not first been separately collected as "non-household" municipal waste, with non-hazardous wastes is therefore permitted.

Article 1(5) of the HWD also states that "the Council shall establish, upon a proposal from the Commission, specific rules taking into consideration the particular nature of domestic waste not later than the end of 1992". No further steps were taken regarding this statement until, in February 1997, the European Commission published a discussion paper regarding a proposed directive on hazardous municipal waste (European Commission, 1997). However, the proposed Directive did not progress further as measures regarding the collection and subsequent disposal of such waste were deemed acceptable in most Member States. It is likely that amendments to the HWD, most likely through integration with the WFD, will remove this statement from Article 1(5).

The EWC provides two classifications of hazardous waste, which are referred to in the UK as "absolute" and "mirror" entries. Both categories of hazardous waste are notified by an asterisk, which acts to separate hazardous wastes from non-hazardous wastes in the list (Table 1). "Absolute entries" are categorized as hazardous regardless of composition or concentration of hazardous substance within the waste. For example, all pesticides in municipal waste (listed under 20 01 19) can be classified as hazardous without assessment of composition. Absolute hazardous waste can be considered to display one or more of the properties (or hazard phrases) listed in Annex III to the HWD (Box 1). "Mirror entries" identify particular waste categories that are only hazardous when they contain a dangerous substance above a certain threshold concentration: hence, two almost identical entries, one hazardous and one non-hazardous, are posted. Dangerous substances are defined in the Dangerous Substances Directive 67/548/EEC, as amended, which also refers to the risk phrases (or R numbers) used to designate a chemical as possessing dangerous properties (European Council, 1967). The Dangerous Preparations Directive 99/45/EC, as amended, lists concentration limits for dangerous substances, with presence above the limit rendering a product or preparation hazardous (European Parliament and Council, 1999). Article 2 of the EWC lists the threshold limits for hazard characteristics H3–H8, H10 and H11 (defined in Box 1): the EWC does not provide concentration specifications for the remaining hazard phrases.

The original Hazardous Wastes List (HWL) 94/904/EC (European Council, 1994) included only five wastes from municipal sources as possessing hazardous properties: paints and similar products, solvents, photochemicals, pesticides, and fluorescent tubes and other mercury-containing wastes. No attempt was made to classify as "absolute" or "mirror", and it is noteworthy that acids and alkalis were not listed. Despite exclusion from the municipal waste hazardous list, many of the wastes that appear in separate waste collections from households were considered hazardous by the HWL in waste streams other than municipal refuse. As such, chlorofluorocarbon-containing equipment, waste wood preservatives, health care waste, acids and alkalis, and waste oils were considered hazardous when arising from industrial and certain commercial uses. Amalgamating the HWL with the non-hazardous listings of the EWC expanded the range of municipal wastes considered hazardous when separately collected, with added qualification of inclusion provided. Further amendments to the resulting Decision 2000/532/EC (European Commission, 2000) introduced wood wastes containing dangerous substances (European Commission, 2001a), re-classified end-of-life vehicles as hazardous for entry 16 01 04 but not for municipal wastes (European Commission, 2001b), and provided further detail concerning classification of oil (European Council, 2001). Inclusion in the amended EWC can be considered to act as a definition of municipal, and hence household, hazardous waste.

Table 1
Municipal Hazardous Waste listed in Chapter 20 of the European Waste Catalogue (European Commission, 2000), notified in the list by an asterisk

Waste category	Six-digit waste specific code
Solvents	20 01 13
Acids	20 01 14
Alkalines[a]	20 01 15
Photochemicals	20 01 17
Pesticides	20 01 19
Fluorescent tubes and other mercury-containing waste	20 01 21
Discarded equipment containing chlorofluorocarbons	20 01 23
Oil and fat other than those mentioned in 20 04 25	20 01 26[b]
Paint, inks, adhesives and resins containing dangerous substances	20 01 27[b]
Detergents containing dangerous substances	20 01 29[b]
Cytotoxic and cytostatic medicines	20 01 31[b]
Mixed batteries and accumulators containing batteries or accumulators included in 16 06 01, 16 06 02 or 16 06 03	20 01 33[b]
Discarded equipment other than those mentioned in 20 01 21 and 20 01 23 containing hazardous components	20 01 35[b]
Wood wastes containing dangerous substances	20 01 37[b,c]

The four-digit prefix, 20 01, indicates separately collected fractions.
[a] "Alkalines" are referred to as a category within the EWC. Elsewhere in this paper, however, the category will be referred to by the more correct terminology of "alkalis".
[b] Hazardous 'mirror' entries – accompanied by a non-hazardous entry. All other waste fractions are 'absolute' entries.
[c] Added to the EWC through Commission Decision 2001/118/EC (European Commission, 2001a).

Seven of the EWC municipal waste entries are considered "absolute" hazards. However, the waste types described vary from particular products to properties of products. Pesticides, photochemicals, equipment containing CFCs and mercury containing equipment (except batteries) are specific products or descriptions of product types. Solvents, acids and alkalis are descriptions of properties of wastes and are notable for their lack of further description. Many of the chemicals used in photographic development (itself an absolute entry) are strongly acidic and hence applicable to at least two EWC categories. More detail is provided elsewhere in the EWC, with different chapters offering more depth to the Chapter 20 description, although these frequently have little bearing on the municipal waste stream. Slack et al. (2004) provided more information on the individual hazardous waste descriptions listed in Chapter 20.

The Landfill Directive, transposed into UK legislation as the Landfill Regulations 2002, also differentiates between non-hazardous, hazardous and inert wastes and the landfills that are permitted to take them (Statutory Instrument, 2002a). Wastes must meet waste acceptance criteria (WACs) in order to be disposed of at one of the three classes of landfill. However waste allowed at hazardous waste sites must firstly be a hazardous waste under the Hazardous Waste Directive and then meet additional criteria before being deposited. Whilst separately collected "absolute" and hazardous "mirror" entries of HHW require WAC testing before disposal method may be determined, HHW co-disposed with municipal solid waste (MSW) need not. Section 2.2.1 of the Waste Acceptance Criteria Decision 2003/33/EC states that "Municipal

waste as defined in Article 2(b) of the Landfill Directive [“municipal waste” means waste from households, as well as other waste which, because of its nature or composition, is similar to waste from households] that is classified as non-hazardous in Chapter 20 of the European waste list, separately collected non-hazardous fractions of household wastes and the same non-hazardous materials from other origins can be admitted without testing at landfills for non-hazardous waste” (European Council, 2003). Unlike other waste streams, co-disposed municipal waste is therefore considered to be non-hazardous irrespective of waste composition. It is therefore possible for HHW to be disposed of alongside MSW in non-hazardous landfills.

Legislation can be seen to define the type of waste that is classified as hazardous. However, until recently, there has been no legislative drive to separate the hazardous proportion of municipal/household waste from non-hazardous waste, despite the differentiation applied to hazardous waste from domestic/household and non-household municipal sources. The WEEE Directive will have a considerable impact on MSW, requiring the separate collection and disposal of a range of household equipment as described in Annex IA and IB of the Directive (European Parliament and Council, 2002a). The recent imposition of the WEEE Directive signals a change of approach, necessitating separate collection of all municipal WEEE. It is possible that other elements of household/MSW will similarly require separate collection as further producer responsibility legislation comes into force, such as the Batteries and Accumulators Directive and the ELV Directive, which has placed responsibility for the disposal of domestic vehicles on the last registered owner (but not the local authority), thus rendering certain ELVs a household fraction. For waste managers handling separately collected fractions of MSW not currently regulated by specific product legislation, the hazard definitions provided by the HWD, Dangerous Substance Directive and related legislation are the sole descriptions available. These classifications are insufficient for accurate identification of problem wastes although the wastes listed in the EWC act as an identification aid.

4. Reducing the environmental impact of HHW

Current UK legislation, enacting EU Directives, does not provide explicitly for the management and definition/classification of HHW. As a result, the situation for both disposers (particularly householders) and waste managers is confusing. No legal requirement exists in the UK for householders to separate HHW from general household waste and if it did, enforcement would be extremely difficult. Therefore, whilst all other hazardous wastes are closely regulated, HHW remains a possible environmental and/or health risk. Both legislation and fiscal measures may assist in mitigating potential environmental and human health impacts.

4.1. Legislation applicable prior to disposal

There are no regulations concerning the specific collection and disposal of HHW in the EU and yet many countries offer collection programmes. In the UK, HHW programmes vary considerably across the country as national policy does not exist and different local authorities place different degrees of emphasis on HHW collection and disposal. The recently implemented HWR provide guidance concerning the point at which separately collected HHW becomes classed as hazardous waste – on removal from HWRC sites (Statutory Instrument, 2005a). Hazardous classification prior to this would render the householder the “producer” and therefore required to complete a consignment note (Ellis, 2005). Without further guidance and with current legislation open to considerable interpretation, there is the possibility that inappropriate disposal decisions will be made, increasing risks to health and the environment. For instance, the hazardous properties listed in the HWD, whilst describing a fairly comprehensive selection of hazards, do not include post-natal developmental effects linked to endocrine disruption. The effects of, for instance, phthalates on hormone balance have garnered general acceptance to such an extent that use of phthalates in children’s toys has been prevented through an amendment to the Dangerous Substances Directive (European Parliament and Council, 2005), an example of the precautionary principle. Nevertheless, evidence of endocrine disruption linked to a range of substances, from amateur-use pesticides to preservatives used in personal care products and household cleaners (Daughton and Ternes, 1999), remains uncertain and application of the precautionary principle across all potential hormone-affecting substances has not been advocated.

It appears that European waste legislation is being developed for individual waste streams due to the introduction of producer responsibility legislation; this is despite a general policy to develop over-arching framework legislation rather than adopt waste stream or product specific legislation. Given the considerable variation that exists between wastes and the different disposal requirements (compare biodegradable wastes with end-of-life vehicles), the trend produced as a consequence of producer responsibility legislation provides a more focused solution to disposal problems. WEEE is the only category falling under the HHW definition that is currently affected by producer responsibility legislation. The WEEE Directive provides a clear definition of items that contribute to the WEEE stream, descriptions lacking from the EWC listing. However, a result of the separate regulation appears to have removed WEEE from consideration as HHW, as demonstrated in a number of recent waste surveys (Burnley et al., 2007; Poll, 2003). It is possible that the implementation of further producer responsibility legislation may affect other HHW categories, aiding interpretation of the individual hazardous wastes as has been shown by the Batteries and Accumulators Directive. This would be particularly useful for ambiguous HHW categories listed in Chapter 20 of the EWC, such as the solvents, acids and alkalis. However, the recent recodification of the WFD and ongoing negotiations to consolidate horizontal and daughter directives, including the HWD, into the framework directive would indicate that separate producer responsibility legislation is unlikely to be developed further. An incentive for further legislation regarding HHW streams has been provided in the LandSim model described by Slack et al. (2007b). WEEE is one waste stream that contains significant quantities of heavy metals and may have been the dominant contributor of heavy metals to MSW landfill leachate as shown in the model. Diversion of WEEE from such landfills, as required by the WEEE Directive, may lead to a reduction in heavy metals within the landfill.

Legislation is in place in most developed countries requiring the toxicological assessment of new chemicals entering the market place, including those destined for household products. This is exemplified in the UK by the Chemicals (Hazards and Packaging) Regulations 2002, or CHIP3 (Statutory Instrument, 2002b). No equivalent has been adopted in the EU, although the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Regulation has recently been ratified (European Parliament and Council, 2006c). Other European-wide legislation relates to particular product groups. The Restriction of Hazardous Substances (RoHS) Directive limits heavy metals in electronic and electrical equipment (European Parliament and Council, 2002b), and the Batteries and Accumulators Directive restricts levels of lead, cadmium and mercury in all consumer batteries. Plant Protection Products Directive and the various Directives influencing human and veterinary medicines further determine whether certain substances can be used in various products (European Council, 1991b; European Parliament and Council, 2004a,b). The EU has introduced

recommendations and regulations restricting or banning the use of, among other chemicals, creosote, chromated copper arsenate wood treatments, and various hair dyes (European Commission, 2001c, 2003, 2006). Hence, identification and exclusion from household products of potentially dangerous new substances or heavy metals is improved, rendering the final waste product less hazardous than older, similar products.

Well-established substances, particularly organic chemicals, are less likely to have had to conform to tests for hazardous properties, although many are currently being assessed in light of evidence from long-standing use. It has been estimated that less than 2% of the 30,000–100,000 synthetic (manufactured or extracted) chemicals available today have been tested for toxicity and even fewer for long-term effects (Allanou et al., 2003a,b; Blundell, 2003); REACH will seek to improve this situation. A growing number of such chemicals are being identified as carcinogens and mutagens, creating demand for stricter regulation. This is particularly important with regard to mixtures of chemicals. Currently, regulations do not require the testing of chemical mixtures provided the component parts have been analysed. As such, the additive, synergistic and antagonistic effects of compounds in mixtures are not considered (Hansen et al., 1998), unsurprising given that so few chemicals are tested individually. It is possible that more substances will become categorized as hazardous and hence have further consequences for the disposal footprint, particularly if the precautionary principle is applied (Blundell, 2003).

Waste legislation has recently undergone a period of considerable development. New legislation has the potential to exert substantial effects upon the waste streams loosely grouped together as HHW. However, more clarification is needed regarding the position of HHW as hazardous waste. Whilst Article 1(5) of the HWD does suggest that such clarification should have been provided, specific rules are still lacking despite a proposed Hazardous Municipal Waste Directive (European Commission, 1997). With European enlargement progressing and given that local authority HHW collection facilities vary considerably in the UK, the situation regarding hazardous wastes of domestic or municipal origin requires further discussion.

Improved definition of the wastes comprising HHW and guidance for waste managers regarding collection and disposal programmes is needed. A European-wide data-gathering project would aid understanding of the particular waste streams, permitting the risks to be fully evaluated and thus determine the need for further legislation. A relatively small-scale UK project demonstrated the predominance of HHW co-disposal with MSW, stressing again the link with landfill emissions (Slack et al., 2007a,b). The UK study also included a number of municipal wastes not classified as hazardous in Chapter 20 of the EWC but possessing a number of properties that concur with the categories described in the HWD. For instance, aerosol cans, or pressurized canisters containing liquids or solids, are not listed in Chapter 20 despite the potential flammability of the contents. End-of-life vehicles, asbestos materials and clinical waste can all arise from domestic situations but are not considered in Chapter 20 despite inclusion in earlier chapters. Asbestos is, however, regarded as hazardous in UK law and disposal from domestic properties requires the completion of consignment notes similar to those available for more conventional hazardous waste. There are other miscellaneous waste groups for which a case exists for inclusion as a separate waste stream in Chapter 20 of the EWC. As discussed earlier, the "emerging" hazards of endocrine disruption along with persistence and bioaccumulation could potentially lead to the re-classification of certain wastes.

Raising public awareness about the wastes within the HHW stream through more accurate labelling of relevant products may assist in diversion of waste from co-disposal at landfill or even question whether the products forming HHW need to be used. Lists of ingredients and other information provided on labels of hazardous products may not contribute to a greater understanding of product risk during use and at disposal (Grey et al., 2005). Box 2 provides examples of the disposal information currently supplied, showing the absence of helpful information relating to disposal options. In the UK, a number of waste disposal authorities have suggested that householders need to be more aware of HHW, both its composition and options available for disposal, and that statutory producer responsibility would aid collection and disposal of HHW (Luckin, 2006). Local authorities in the UK are not currently required by law to make available HHW collection facilities, making it difficult for householders to identify whether their local HWRC site has the "special facilities" required for HHW disposal (Box 2). Hence, it is crucial that any decisions regarding raising HHW awareness, improving labelling advice and providing a standardized collection programme occur concurrently and involve all stakeholders from manufacturers to householders and waste managers.

4.2. Mitigating risk after disposal

Methods adopted for the disposal of waste have been governed by a number of factors, including topography, cultural disposal patterns and financial pressures. In the UK, the use of landfills reflects the historically low costs associated with back-filling mineral extraction sites. However, waste disposal has increasingly been affected by legislation, principally through the Landfill Directive, with mounting pressure to divert waste from landfill. This has particularly important consequences for the UK, which, in certain regions, disposes of 80% of municipal waste to landfill (Defra, 2005). The availability of alternatives such as incineration is limited but as landfills close with fewer sites granted permits, stricter landfill regulations (the separation of hazardous, non-hazardous and inert waste to specific landfills) and the rising costs of landfilling, the demand for non-landfill disposal will increase. However, disposal to landfills cannot cease entirely as the end product of many waste treatments or "alternatives" to landfill require disposal somewhere. For incineration, this will prove very problematic as air pollution control residues (listed as Annex I.B(28) in the HWD) derived from MSW incineration can no longer be disposed of to MSW landfills under EU law, and require significant treatment if they are to meet waste acceptance criteria for disposal at hazardous waste landfills. Similarly, should incinerator bottom ash (Annex I.B(22) in the HWD) demonstrate any of the properties listed in Annex III or any constituents listed in Annex II of

Box 2. Examples of disposal advice currently offered to householders. The phrase "some local authorities have special facilities…." does not help the householder determine how to dispose of the waste.

Paint & varnish remover (Focus (DIY) Ltd.)

"Health Safety and Environment:

> Avoid release to the environment. This material and/or its container must be disposed of as hazardous waste. Some local authorities have special facilities for the disposal of waste material."

Exterior water-based wood paint (ICI Dulux Weathershield)

> "Do not empty into drains or watercourses. Some local authorities have special facilities for disposing of waste paint."

the HWD, treatment as hazardous waste will result. Furthermore, the cost of hazardous waste landfilling is expected to rise as the Landfill Directive is gradually implemented in the UK, reflecting the cost of the additional measures required by the Directive and the shortage of facilities. This could have a considerable effect upon separately collected HHW and the risks posed to the environment: separately collected HHW tends to be disposed of through incineration and the subsequent disposal of residues to landfill.

Classification of HHW as hazardous waste introduces levels of complexity to collection and disposal management. As the HWD and Landfill Directive exempt HHW co-disposed with residual MSW from classification as hazardous and from meeting waste acceptance criteria for disposal at non-hazardous waste landfills, there are economic and practical incentives to maintain, possibly even encourage, such disposal to landfills. However, the new Waste Strategy for England demonstrates that the Department for Environment, Food and Rural Affairs (Defra) means to consider measures to encourage separately collected HHW (Defra, 2007) and there are increasing drives to separately collect HHW streams in the UK, partly because of individual waste stream legislation exemplified by the WEEE Directive.

The Landfill Directive is also driving a change in the types of material permitted to be disposed of to landfill. This is particularly evident through the diversion of biodegradable waste. In unsorted MSW, biodegradable waste has been estimated to contribute at least 20% of the mass and HHW approximately 4% (including WEEE). Reduced biodegradable matter increases the relative proportions of HHW (and other waste types) in MSW. Increased recycling rates for paper, glass etc., contributing >40% to MSW, will boost the HHW proportion further. Leachate from existing and new landfills will be expected to be very different to leachate from older/closed sites due to changes in the composition of landfilled waste. The consequences for the hazardous component of MSW require further evaluation, although a decline in organic matter can be expected to result in leachates containing predominantly inorganic ions. The impact on the sorption of XOCs and heavy metal attenuation may be beneficial, reducing the mobility of hazardous species. Changes to leachate treatment techniques will be necessitated and the long-term management of landfills adjusted.

Based on pre-Landfill Directive waste composition, and assuming that HHW is responsible for many of the XOCs and metals in MSW landfill leachate, the risk to the environment and human health through groundwater pollution is relatively small from engineered landfills, despite the relatively high concentrations of heavy metals (Slack et al., 2007b). Older landfills may, however, be of greater concern. Whilst post-Landfill Directive changes and the consequences for HHW have yet to be examined, it would appear that the requirements made will not provide any further mitigation of risks than currently offered through engineered landfills and leachate treatment. Despite rising landfill costs and taxes, incineration remains financially the more expensive option, particularly if incineration residues fail to meet the waste acceptance criteria. The introduction of tighter regulations concerning the chemical content of potentially hazardous consumer products may render HHW less problematic. The risks associated the various HHW disposal techniques and comparison with landfill to assess the impact of hazards on the environment and human health require further evaluation.

5. Conclusions

Household hazardous waste (HHW) is not defined in EU or UK legislation, although various, often opaque, references are made to it in the text of the Hazardous Waste Directive and the European Waste Catalogue, both transposed into UK regulations. HHW consists of a range of waste streams, some of which have been the subject of specific legislation, possessing a number of hazardous properties. Whilst separately collected fractions of HHW are considered hazardous, this classification does not apply to HHW co-discarded with general non-hazardous municipal waste. HHW is affected by an array of new legislation that will have consequences for both the composition of HHW (e.g. render it less hazardous) and how it is disposed of once collected. Currently in the UK, most HHW is co-disposed to MSW landfills where it contributes to leachate formation, although leachate collection/treatment and natural attenuation help mitigate environmental effects should the engineered landfill barriers fail. However, changes to the Landfill Directive may lead to a proportional increase in HHW as well as changes to the formation and composition of leachate. Alternative disposal methods may need to be evaluated, including the separate disposal of HHW from MSW. This might lead to the need for specific policy/legislation requiring separate collection of HHW from point of discard. Improved public awareness, especially through labelling, would then be necessary as current mechanisms are insufficient. HHW must therefore be considered when evaluating the consequences that current and new waste legislation have on the environment.

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